

# Tropical Rainfall Measuring Mission

## TRMM: Data Products and Usage

NASA Remote Sensing Training  
Norman, OK  
June 19-20, 2012

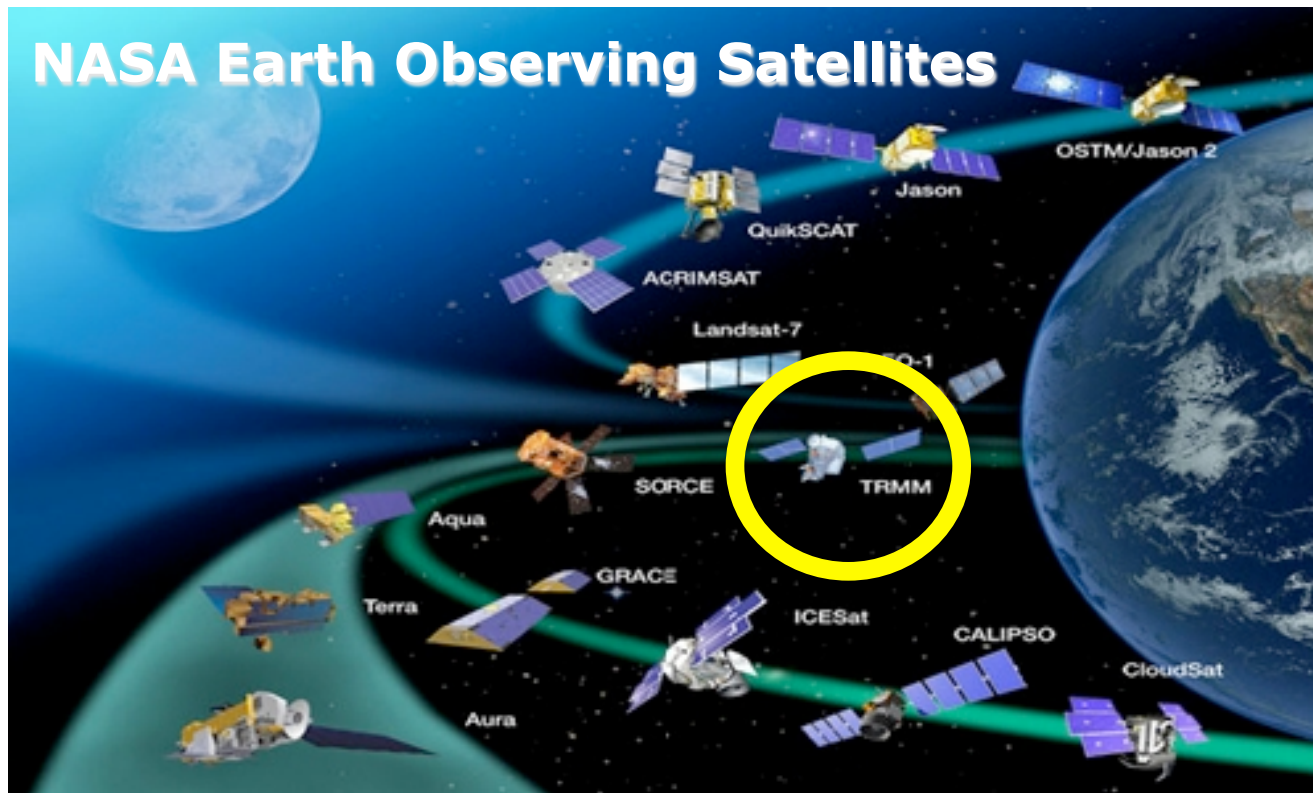
**ARSET**  
**Applied Remote Sensing Training**

A project of NASA Applied Sciences



# Tropical Rainfall Measuring Mission TRMM

<http://trmm.gsfc.nasa.gov/>



# What Is TRMM?

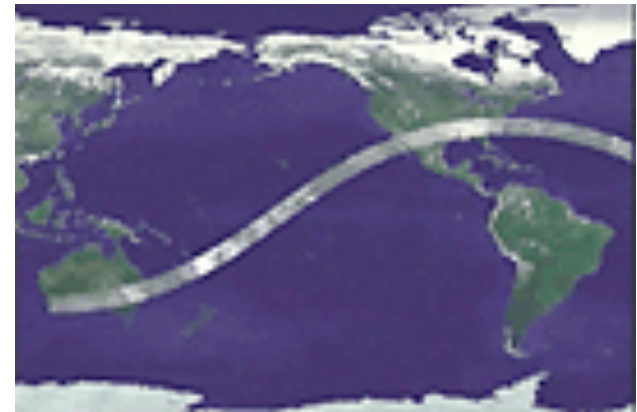
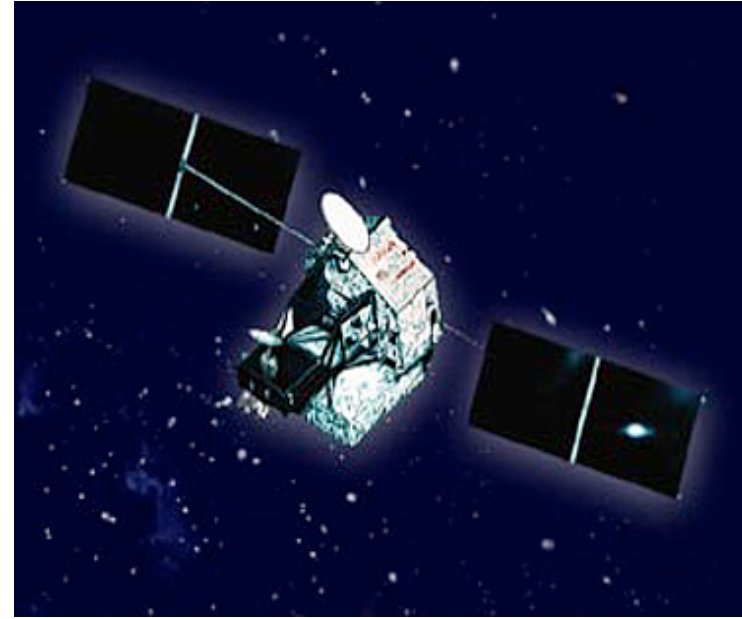
The first satellite mission dedicated to measuring tropical and subtropical rainfall

A collaborative mission between NASA and Japanese space agency

Launched on 27 November 1997

Approximate dimensions: 2.4m x 2.4m x 4.4m

Approximate weight: 3,500kg

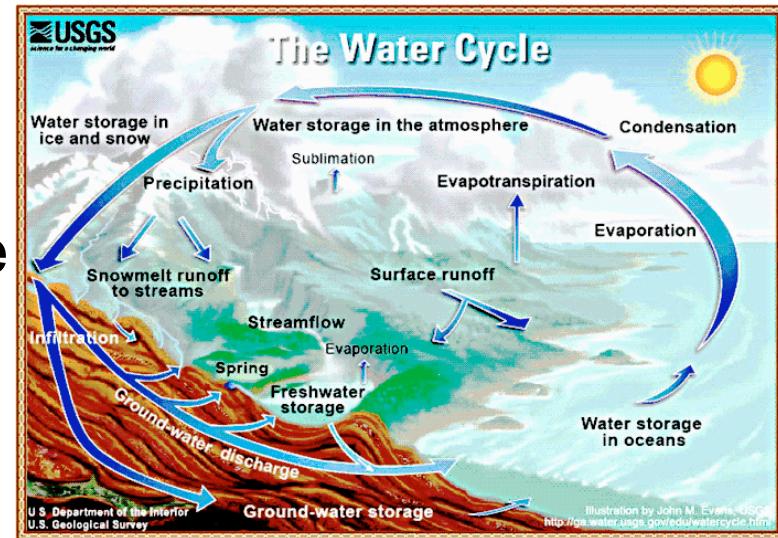


# Why TRMM ?

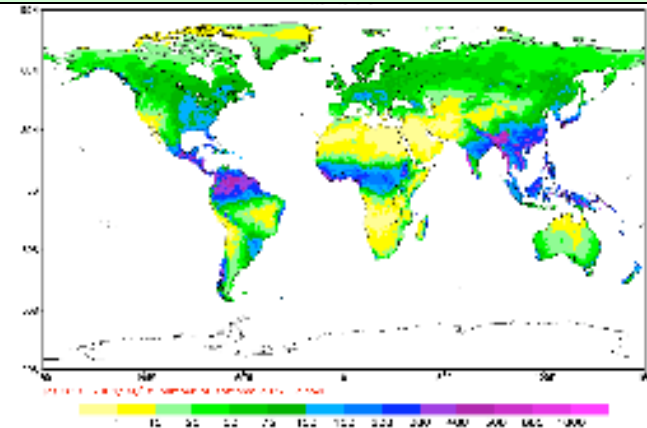
Because:  
**accurate measurements of rain are crucial** -- rain is extremely important for weather, climate, and energy cycle of the earth

**tropical rainfall**, plays a critical role in driving atmospheric motion releasing latent heating --  $\frac{2}{3}^{\text{rd}}$  of the global rainfall occurs in the tropics

information on intensity and amount of rainfall in the tropics was incomplete – especially over oceans prior to satellite coverage

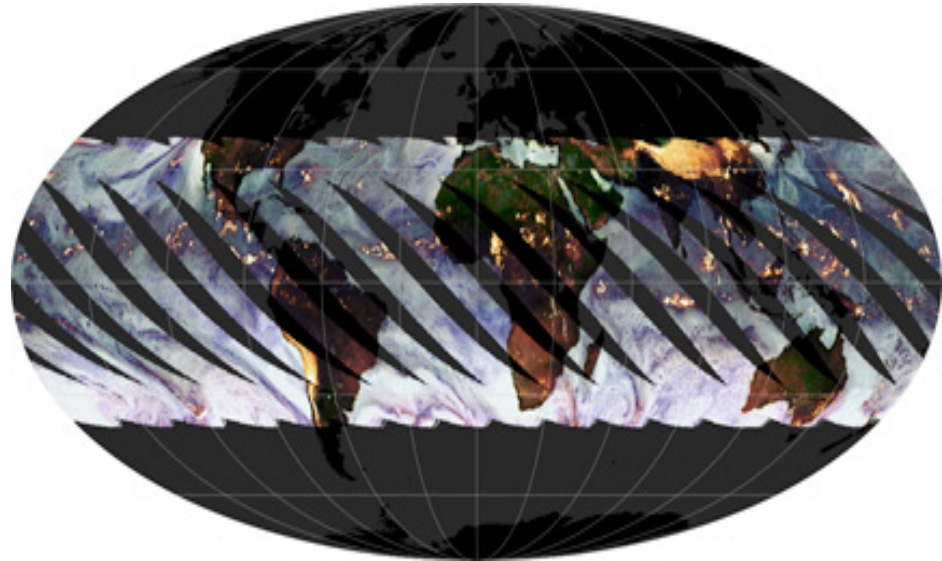


Rain gauge coverage over Land



# TRMM Satellite and Orbits

- TRMM is in a non-polar, low inclination orbit launched at the altitude of approximately 350 Km
- The Orbit was raised to 403 Km after 23 August 2001
- There are 16 TRMM orbits a day, approximate period of 92 minutes, covering global tropics
- TRMM provides global coverage between 35° S to 35°N latitudes



TRMM's low orbital inclination—just 35° from the equator—allows its instruments to concentrate on the tropics. This image shows one half of the observations TRMM makes in a single day.



# TRMM Instruments

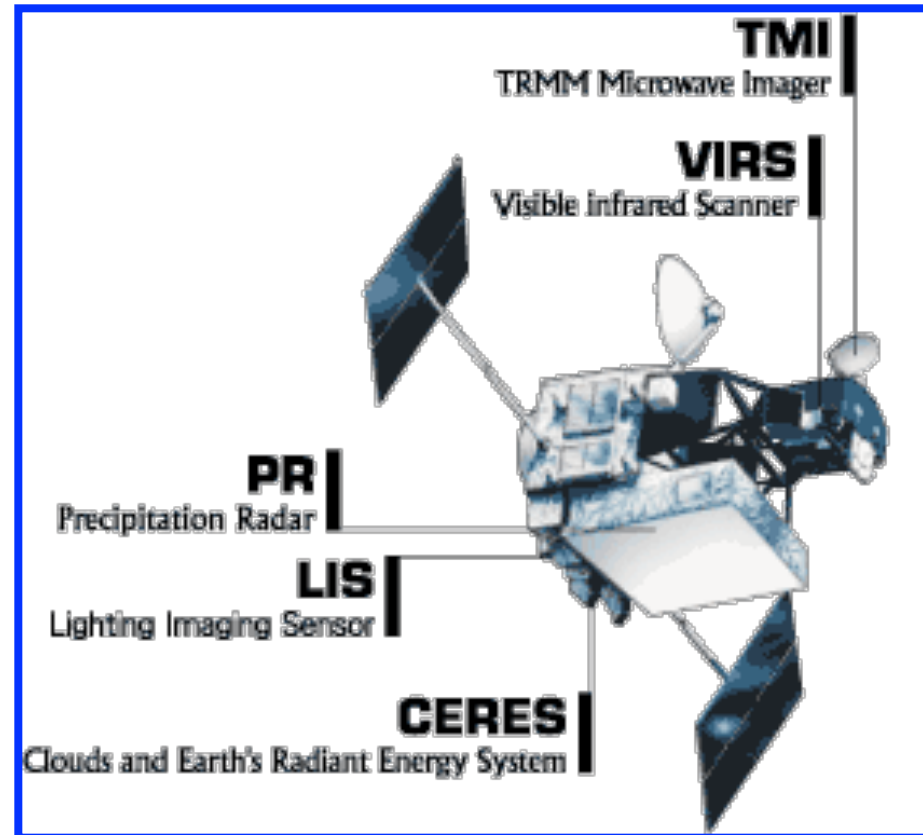
Precipitation Radar (**PR**)  
(First rainfall sensing radar in Space)

TRMM Microwave Imager (**TMI**)

Visible and Infrared Scanner  
(**VIRS**)

Clouds and Earth Radiant  
Energy System (**CERES**)

Lightening Imaging Sensor (**LIS**)



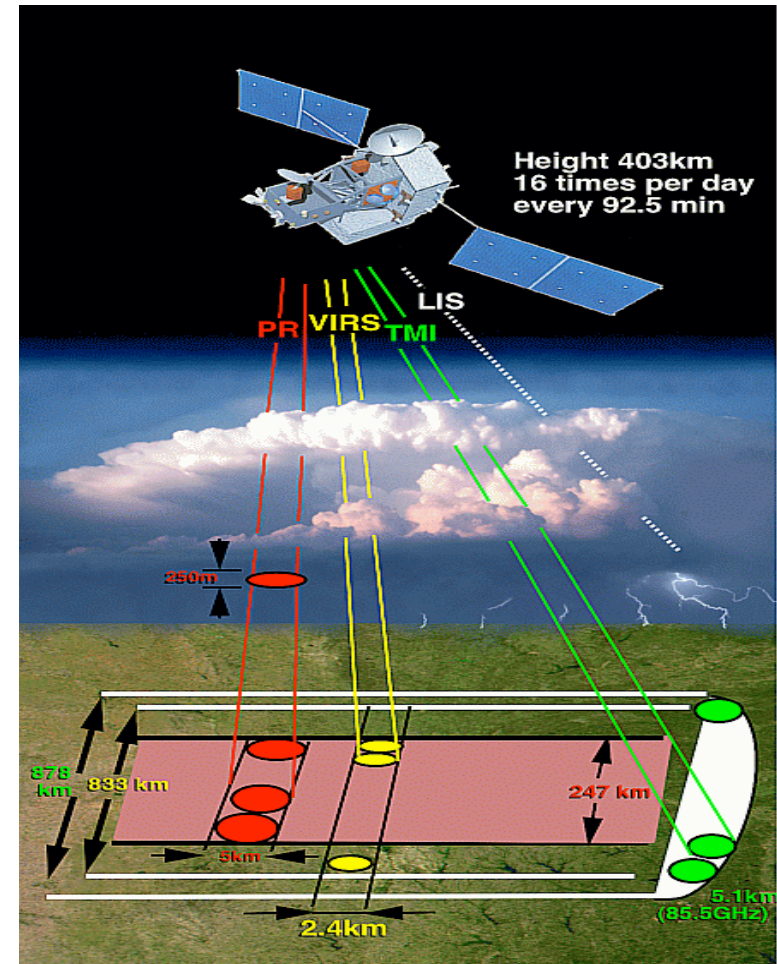
# TRMM Rain Sensing Instruments

TRMM - PR, TMI, and VIRS are used for rainfall remote sensing

The **PR** is an **active instrument** whereas TMI and VIRS are **passive instruments**

Each instrument compliments rainfall measurements

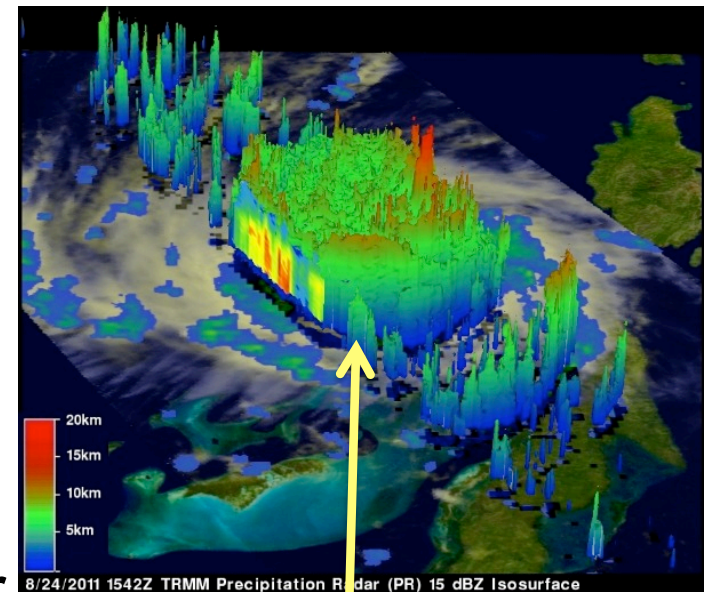
Complex algorithms are involved in determining rainfall intensity, amount, and extent from each instrument



# TRMM Precipitation Radar (PR)

- First space borne instrument to provide three-dimensional maps of storm structure and provide a quantitative rainfall measurement over ocean and land (frequency 13.8 GHz)
- 247 km swath width x **5 km instantaneous field of view**
- Can provide vertical profiles of rain and snow from the surface to 20 km
- Can detect rain as little as **0.7 mm per hour**
- A radar frequency about three times higher than that of ground radar provides good resolution and higher quality images

## TRMM PR Reflectivity Hurricane Irene



Vertical  
profiles



# Rainfall Products from TRMM PR

## **Level 1 & 2:            Orbital Data**

Swath:                      220 km (247 km after orbit change)  
Resolution:              4-5 km horizontal, 250 m vertical  
Data Format:              Compressed HDF

### **Name                      Quantity**

**1B21**                      Radar Power

**1C21**                      Radar Reflectivity

**2A21**                      Radar Surface  
Cross Section

**2A23**                      Radar Rain Characteristics  
(rain type, storm, freezing, and bright band heights)

**2A25**                      Radar Rain Rate, Reflectivity, and Attenuation  
Profile

# Rainfall Products from TRMM PR

## Level 3: Gridded Data

**Resolutions:**

- 0.5°x0.5° and 5°x5° latitude-longitude (for a latitude band from 40°N to 40°S)
- Monthly
- 2, 4, 6, 10, 15 km vertical levels

**Data Format:** Compressed HDF

## Name

## Quantity

### 3A25

Total and **conditional** Rain Rate, Radar Reflectivity, path-integrated attenuation for rain Type, Freezing and Bright Band Heights, and Snow-ice Layer Depth

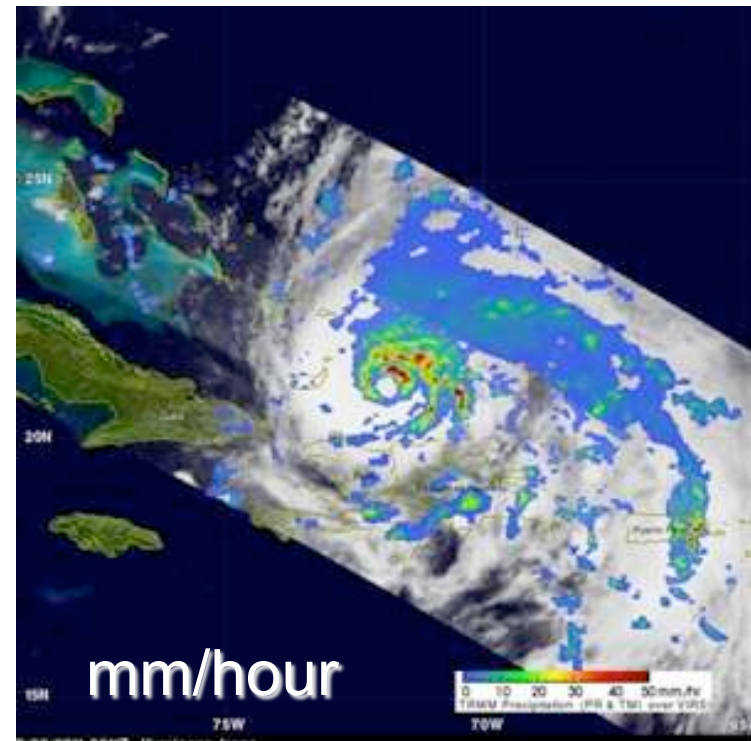
### 3A26

Rain Rate Probability Distribution at surface, 2 km, and 4 km

# TRMM Microwave Imager (TMI)

## TMI Rain Rates - Hurricane Irene

- Passive microwave sensor measuring accurate rain rates
- Frequency (GHz) and polarization are: 10.65 (dual), 19.35 (dual), 22.235 (single), 37.0 (dual), and 85.5 (dual)
- 878 km swath width x 5.1 km field of view (at 85.5GHz)



# Rainfall Products from TRMM TMI

## **Level 1 & 2 :      Orbital Data**

Swath: 760 km (870 km after orbit boost)  
Resolution: 5 to 45 km horizontal (channel dependent),  
14 vertical levels up to 18 km  
Data Format: Compressed HDF

<b>Name</b>	<b>Quantity</b>
-------------	-----------------

<b>1B11</b>	Microwave Radiances and Brightness Temperatures with Geolocation Information
<b>2A12</b>	Hydrometeor (cloud, rain, ice/snow particles) Profiles, Latent Heating Profiles

# Rainfall Products from TRMM TMI

## Level 3:

## Gridded Data

### Resolutions:

- 0.5°x0.5° latitude-longitude, 14 Levels (for a latitude band from 40°N to 40°S)
- Monthly

### Data Format:

Compressed HDF

## Name

## Quantity

### 3A12

Temperature Profiles, Water Vapor Profiles, Rain, Precipitation Rate, Cloud Liquid Water/Ice Water, Atmospheric Heating



# Rainfall Products from Combined PR-TMI

## Level 2 :

**Resolutions:** Swath (5 Km x 247 Km)  
(for a latitude band from 40°N to 40°S)

**Data Format:** Compressed HDF

**Name**

**Quantity**

**2B31**

Surface precipitation Rate, Latent heating Profile

## Level 3 :

**Resolutions:** 5°x 5° (for a latitude band from 40°N to 40°S), Monthly

**Data Format:** Compressed HDF

**Name**

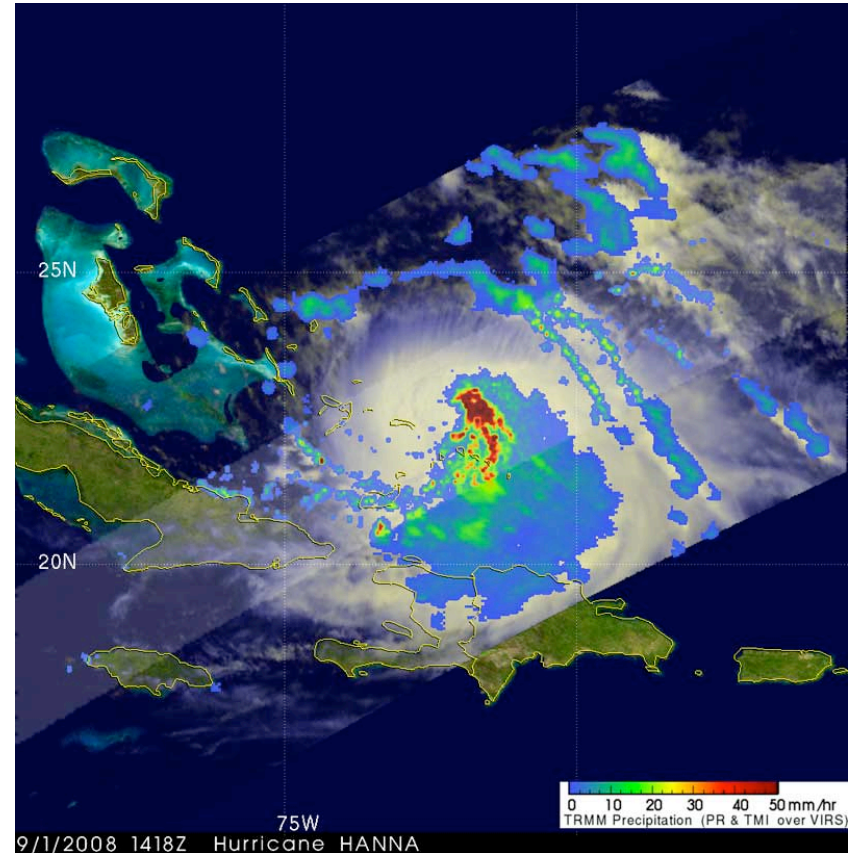
**Quantity**

**3B31**

Surface precipitation Rate, Latent heating Profile

# Visible and InfraRed Scanner (VIRS)

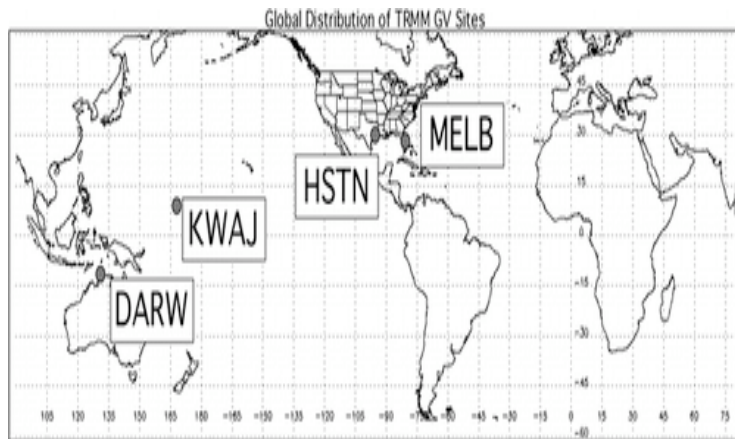
- Measures radiation emitted from Earth in 5 spectral regions, visible to infrared (0.63 to 12  $\mu\text{m}$ )
- 833 km swath width x 2.4 km FOV
- Delineates rainfall and helps calibrate TRMM measurements with those of Polar Orbiting Environmental Satellites (POES) and Geostationary Operational Environmental Satellites (GOES)



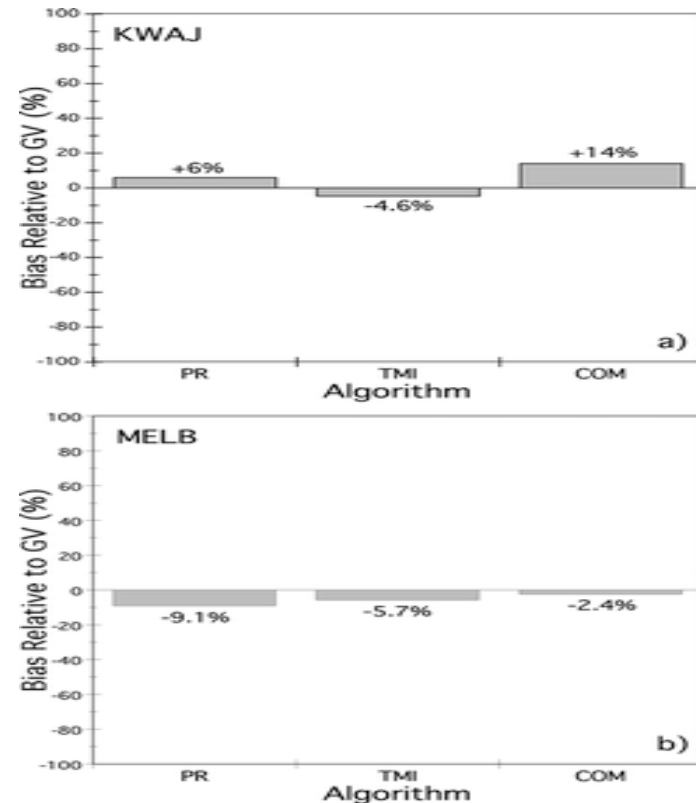
**Hurricane Hanna (9-1-2008)**  
**PR & TMI over VIRS**

# TRMM Ground Validation

(From Wolff et al., 2005 : J Atmospheric and Oceanic Technology)



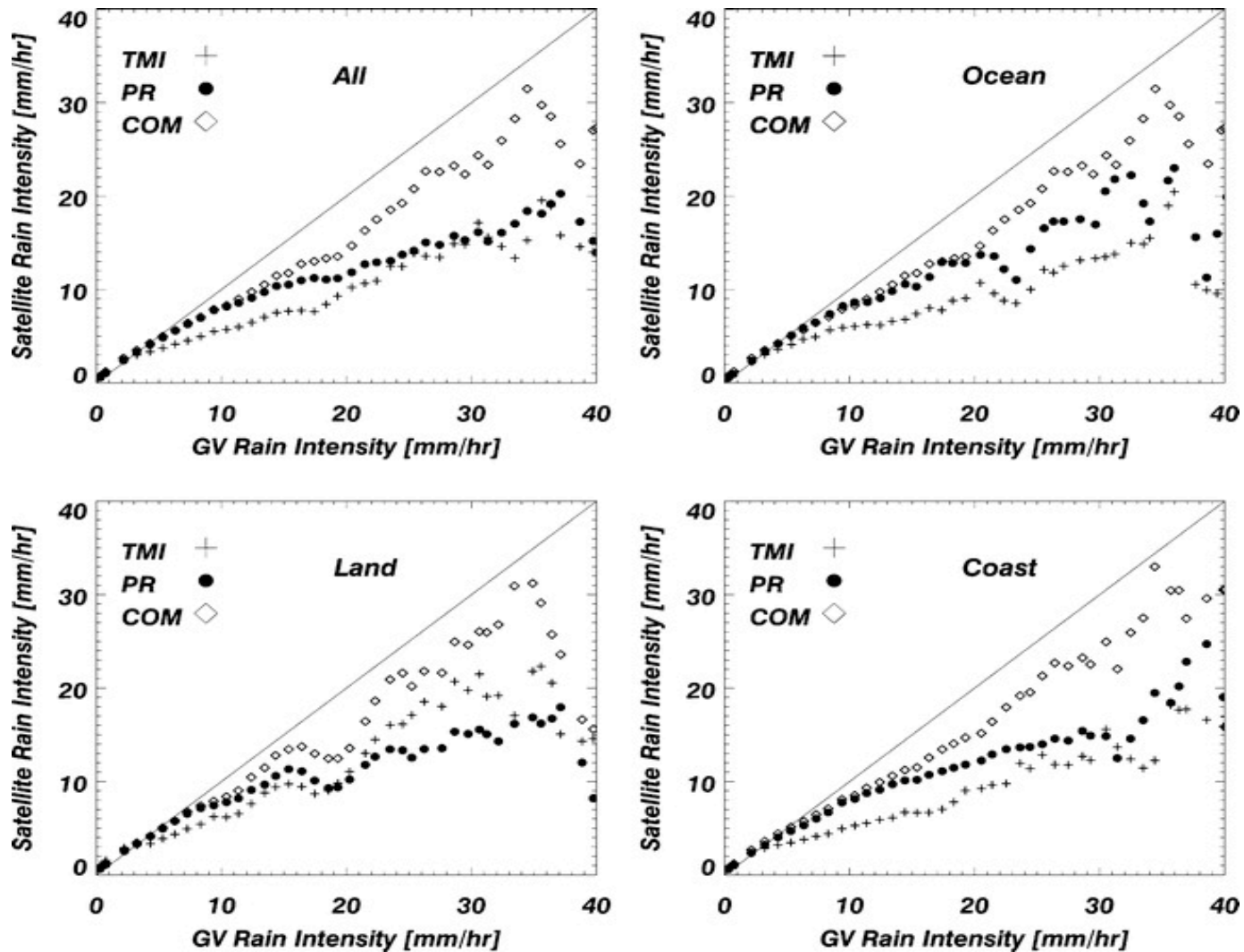
Global map showing locations of the four TRMM GV sites: DARW (Darwin, Australia); HSTN (Houston, TX); KWAJ (Kwajalein, Republic of the Marshall Islands); and MELB (Melbourne, FL).



Bias of TRMM satellite estimates relative to GV for the period Jan 2001–Apr 2002 for (a) KWAJ and (b) MELB. These biases are calculated by comparing the mean rain rate over  $0.5^\circ \times 0.5^\circ$  pixels in the GV domain. Only pixels that were considered as “ocean” by the TRMM satellite algorithms are shown.

# TRMM Ground Validation

(From Wolff and Fisher, 2008 : J Atmospheric and Oceanic Technology)



Comparisons of the TMI, PR, and COM mean rain intensities vs the mean rain intensities of the GV radar at MELB. Rain-rate profiles for (top left) all matched data points; (top right) ocean only, (bottom left) land only, and (bottom right) coast only. (based on 1999-2004 data]

# Derivation of Rain Rate and Rain Amount TRMM Product 3B42

**(The present training sessions will use this data)**

The TRMM 3B42 inter-calibrates and combines PR and TMI rain rates with rain rates from SSMI, AMSR and AMSU-B precipitation estimates, and rain rate estimates from geostationary and low earth orbiting satellites infrared measurements.

Final rain product is calibrated with rain gauge analyses on monthly time scale.

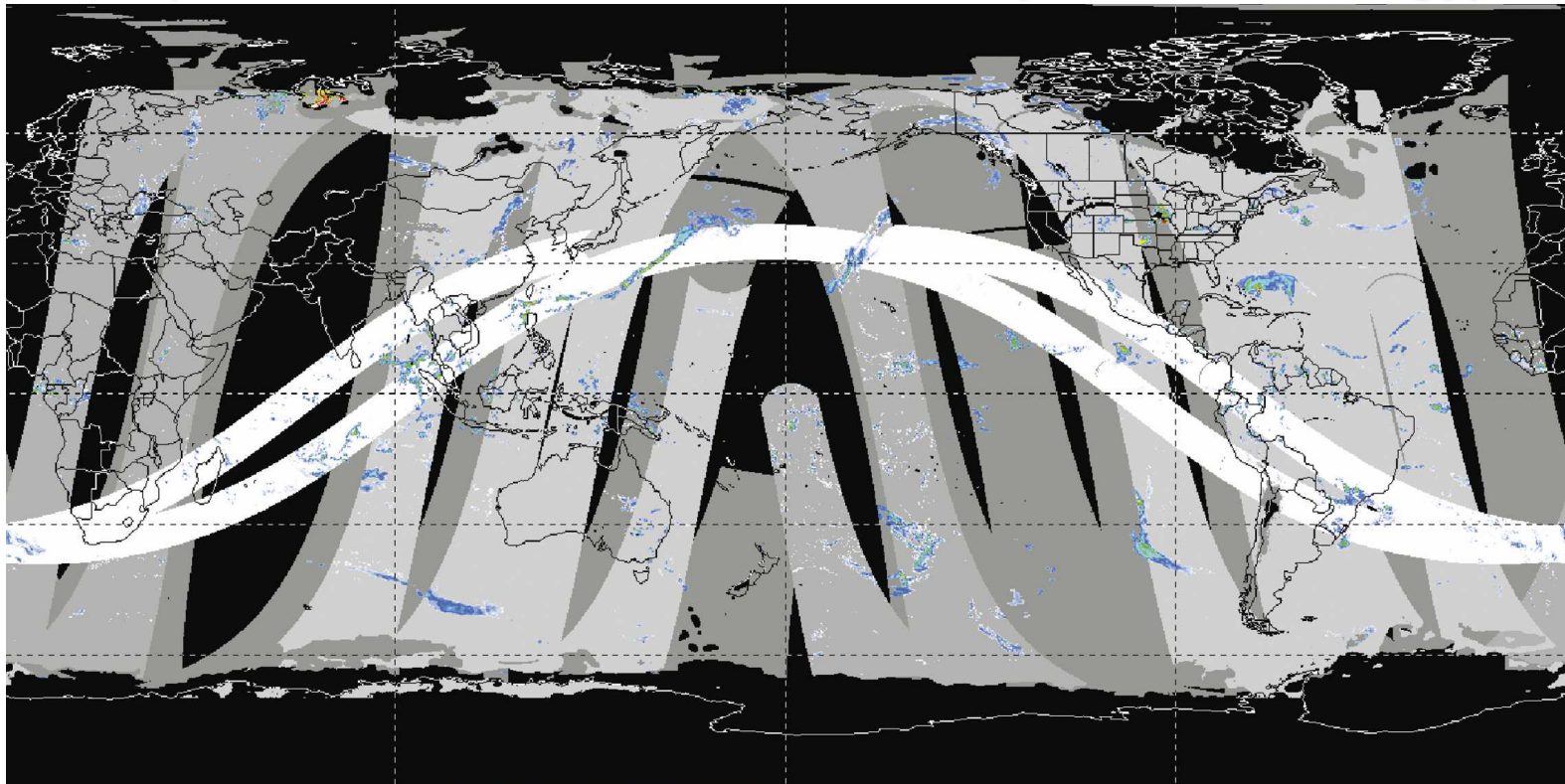
SSMI: Special Sensor Microwave Imager

AMSR: Advanced Microwave Scanning Radiometer

AMSU: Advanced Microwave Sounding Unit



# The TRMM Multi-satellite Precipitation Analysis – Combined Microwave Estimates (From Huffman et al. 2006, J. of Hydrometeorology)



Combined microwave precipitation estimate for the 3-h period centered at 0000 UTC 25 May 2004 in mm h<sup>-1</sup>. Blacked-out areas denote regions that lack reliable estimates, while the zero values in the remaining areas are color-coded to depict the coverage by the various sensors. The order of precedence for display and corresponding zero color are TMI (white), SSM/I (light gray), AMSR-E (medium gray), and AMSU-B (dark gray). (In the TMPA the TMI, SSM/I, and AMSR-E are averaged where overlaps occur.)

# TRMM Multi-satellite Merged Product

## Level 3:

## Gridded Data

### Resolutions:

- 0.25°x0.25° latitude-longitude  
(for a latitude band from 50°N to 50°S)
- 3-hourly, Daily, Monthly

### Data Format:

Compressed HDF

## Name

## Quantity

**3B42**

3-hourly and daily rain rates

**3B43**

Monthly averaged rain rates

Monthly climatology and anomalies

# Obtain TRMM Products

All the TRMM products (Level-1 , -2, and -3) can be downloaded from <http://mirador.gsfc.nasa.gov> by a keyword search. Also, can search by time and location/region

The screenshot shows the Mirador Earth Science Data Search Tool interface. The browser address bar displays <http://mirador.gsfc.nasa.gov/>. The page features a navigation menu on the left with options like + GES DISC Home, + OVERVIEW, + HELP CENTER, + DATA HOLDING, and + VIEW CART. The main search area includes a 'Keyword' field with 'TRMM' entered, a 'Location' field with '(-45,-76),(15,-50)', and a 'Time Span' section with 'From: 2011/05/14' and 'To: 2011/05/21'. A 'Search GES-DISC' button is present. The page also lists available data sources, what's new, and latest news.

**Mirador**  
Data Access Made Simple

You are here: [Keyword Search](#)

**Keyword:** TRMM

**Location:** (-45,-76),(15,-50)

**Time Span**  
**From:** 2011/05/14  
**To:** 2011/05/21

[Search GES-DISC](#)

[Advanced Search](#)

**Available:** [AIRS, OMI, MLS, HIRDLS, TOMS, UARS, TRMM, GLDAS, SORCE, Subsets from A-Train Sensors \(e.g MODIS, AIRS, OMI and MLS\), MERRA, GOCART, LIMS, MSU, NEESPI, NLDAS, SSBV, SBUV, TOVS ACOS MEASURES](#)

**What's New:** [Quality Screening for AIRS Level 2 Products is now combined with Variable Subsetting and NetCDF Conversion](#)

**Acknowledgements:**  
**Location Gazetteer data from:** [National GeoSpatial Information Agency](#)  
**Events Gazetteer data from:** [Univisys](#), [EPA](#) and [Smithsonian Global Volcanism Program](#)

**LATEST NEWS**

**2011-11-03T17:58:49Z - TRMM Version 7 data are now available**  
Tropical Rainfall Measuring Mission provides vital precipitation data  
[+ Read More](#)

**2011-11-03T14:35:18Z - Research papers utilizing Giovanni appear in a flurry during autumn 2011**  
Total number of papers exceeds 400; 2011 citations already equal 2010 tally  
[+ Read More](#)

**2011-10-21T17:07:59Z - ACOS in preparation for new release of CO2 data**  
ACOS Team is preparing to release data from the new version 2.9 build  
[+ Read More](#)

# TRMM and Multi-satellite Merged Products 3B42 and 3B43 On-line Visualization and Analysis Can be Conducted on:

<http://disc.sci.gsfc.nasa.gov/giovanni/>

TRMM Online Visualization and Analysis System (TOVAS)

<http://disc2.nascom.nasa.gov/Giovanni/tovas/>

Most Visited - Getting Started 12th Plinius Confere... Latest Headlines Yahoo! Utton Center

TRMM Online Visualization and A...

**Near-Real-Time Monitoring Product (For research, use Archive Data.)**

Experimental Real-Time TRMM Multi-Satellite Precipitation Analysis (TMPA-RT): 3B42RT	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Daily Global and Regional Rainfall (TMPA-RT 3B42RT derived)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
TMPA-RT Intermediate IR Product: 3B41RT (VAR)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
TMPA-RT Intermediate Microwave Product: 3B40RT (HQ)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>

**Rainfall Archives**

Monthly Global Precipitation (GPCP)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Prototype Interactive Intercomparison of Rainfall Products	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
3-hourly TRMM and Other Rainfall Estimate (3B42 V6)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Daily TRMM and Other Rainfall Estimate (3B42 V6 derived)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Monthly TRMM and Other Data Sources Rainfall Estimate (3B43 V6)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Monthly Rainfall (3B43 V6) Anomaly	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Inter-Comparison of Rainfall Climatology	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Monthly TMI rain, latent heat, cloud liquid water profiles (3A12 V6)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Monthly Rainfall (3A25 V6)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>

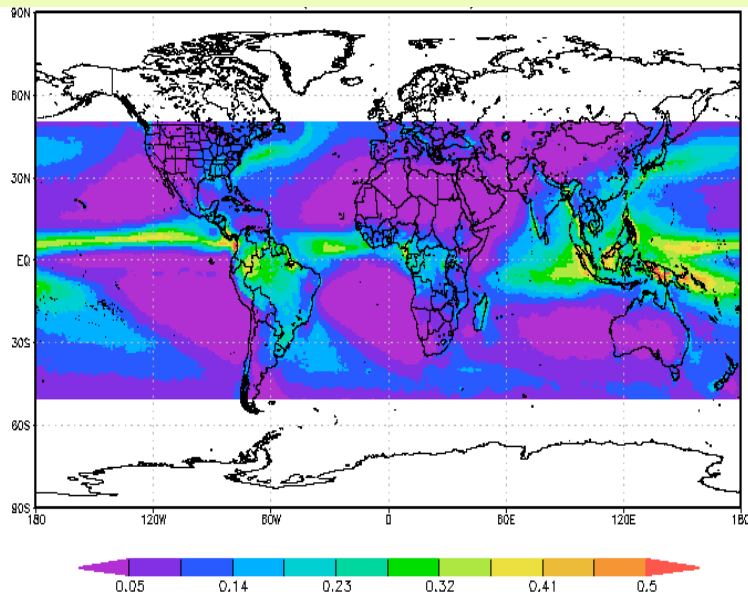
**Ground Observation Archives**

Monthly Willmott and Matsuura Global Precipitation (1950 - 1999)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>
Monthly GPCC Rainfall (1986 - Present, Monitoring Product)	<a href="#">JAVA Version</a>	<a href="#">Non_JAVA Version</a>

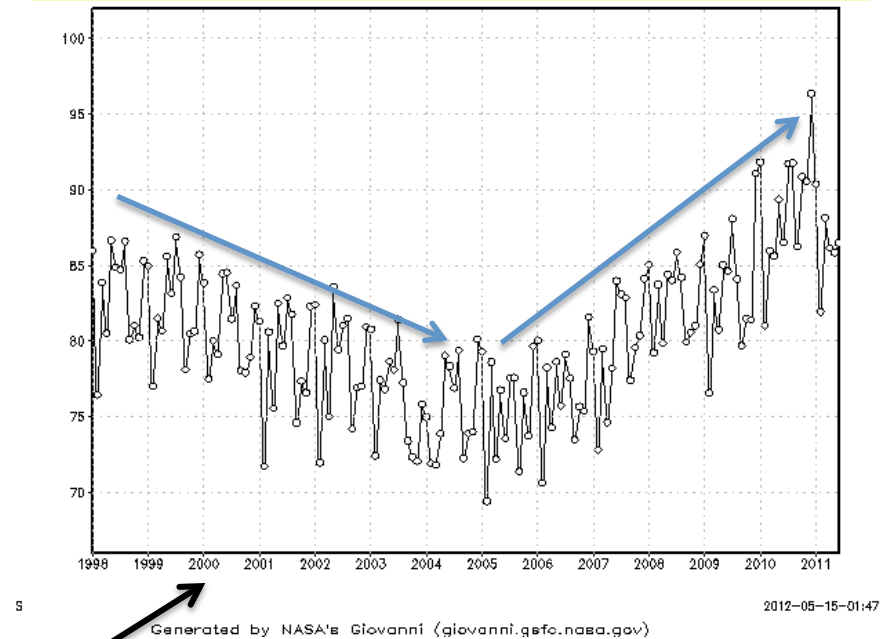
Done

# TRMM Data for Global Climate

Mean Rain Rate (mm/hours)  
Jan1998-Jun2011



Monthly Accumulated Tropical  
Mean Rain (mm)

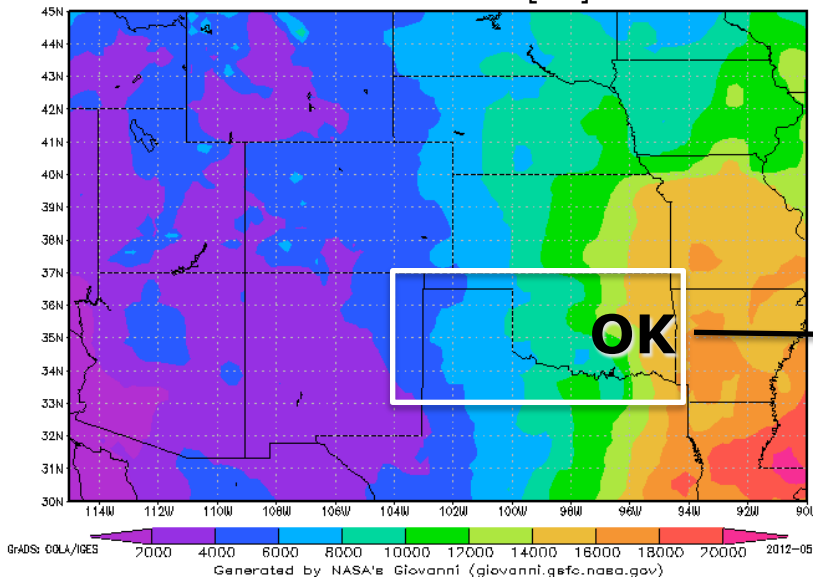


Note the decreasing and increasing nature of the tropical-subtropical rainfall

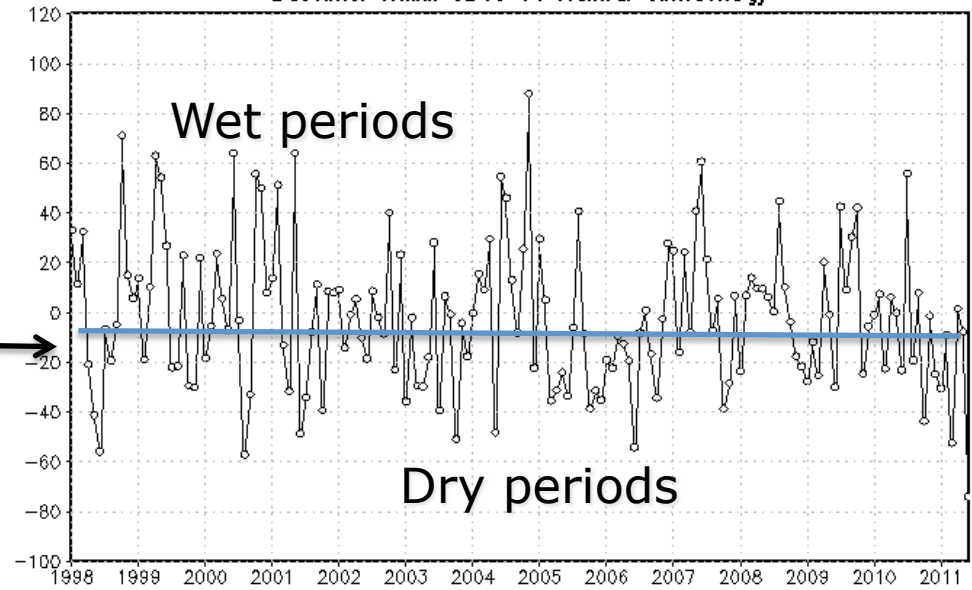


# TRMM Data for Regional Climate

Monthly TRMM 3B43(V6) Jan1998-Jun2011  
Accumulated Rainfall [mm]

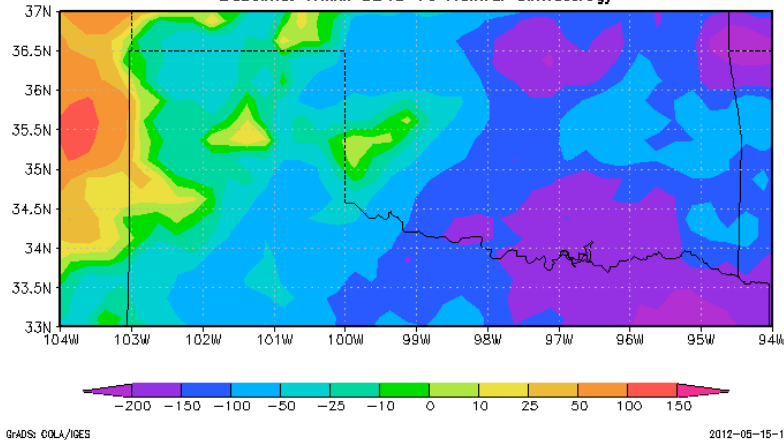


Monthly TRMM 3B43(V6) (Lat: 33N-37N, Lon: 104W-94W)  
Rainfall Anomaly [mm]  
Baseline: TRMM 3B43 V6 Rainfall Climatology

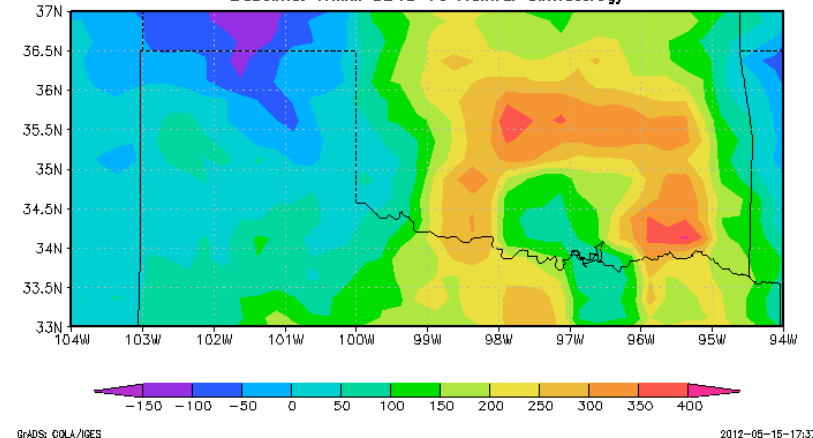


Anomalies are defined as deviation from long-term average values

Monthly TRMM 3B43(V6) (May2006-Aug2006)  
Rainfall Anomaly [mm]  
Baseline: TRMM 3B43 V6 Rainfall Climatology



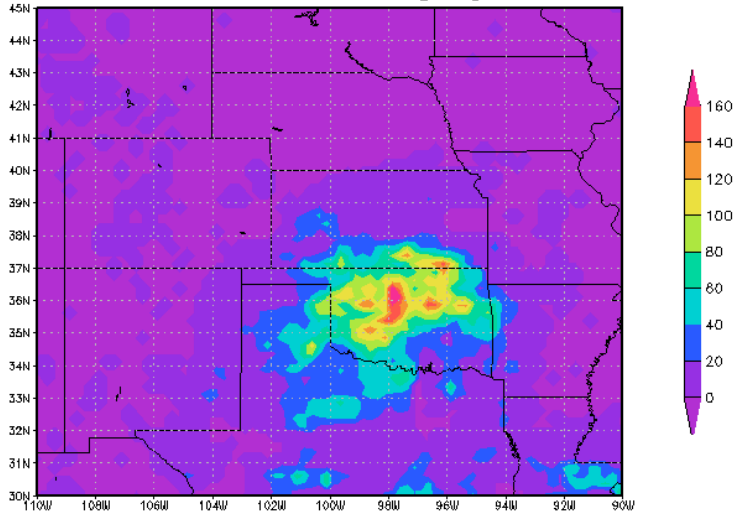
Monthly TRMM 3B43(V6) (May2007-Aug2007)  
Rainfall Anomaly [mm]  
Baseline: TRMM 3B43 V6 Rainfall Climatology



# TRMM for Weather

## Extreme Rain Event of June 20, 2007

Daily TRMM 3B42(V6) 20Jun2007  
Accumulated Rainfall [mm]

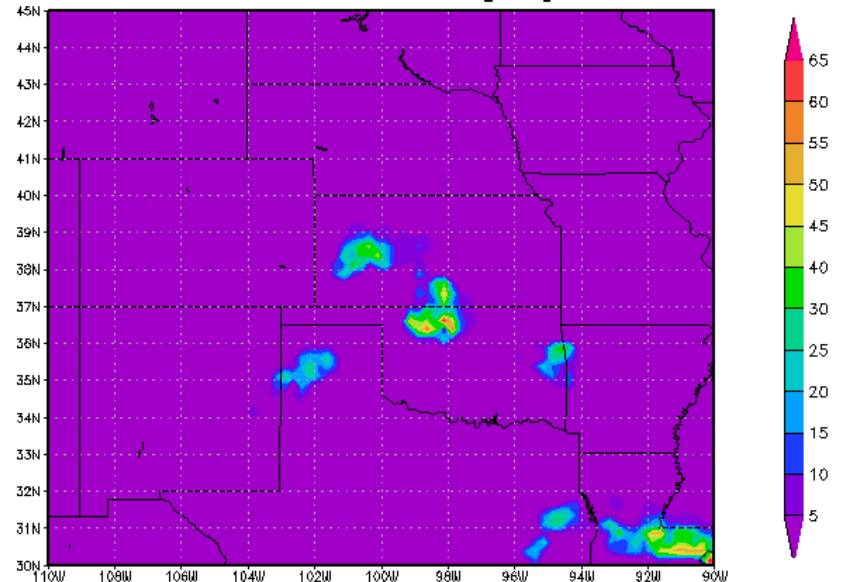


GrADS: COLA/IGES

Generated by NASA's Giovanni ([giovanni.gsfc.nasa.gov](http://giovanni.gsfc.nasa.gov))

2012-05-11

3-hourly TRMM 3B42(V6) 00Z20Jun2007  
Accumulated Rainfall [mm]



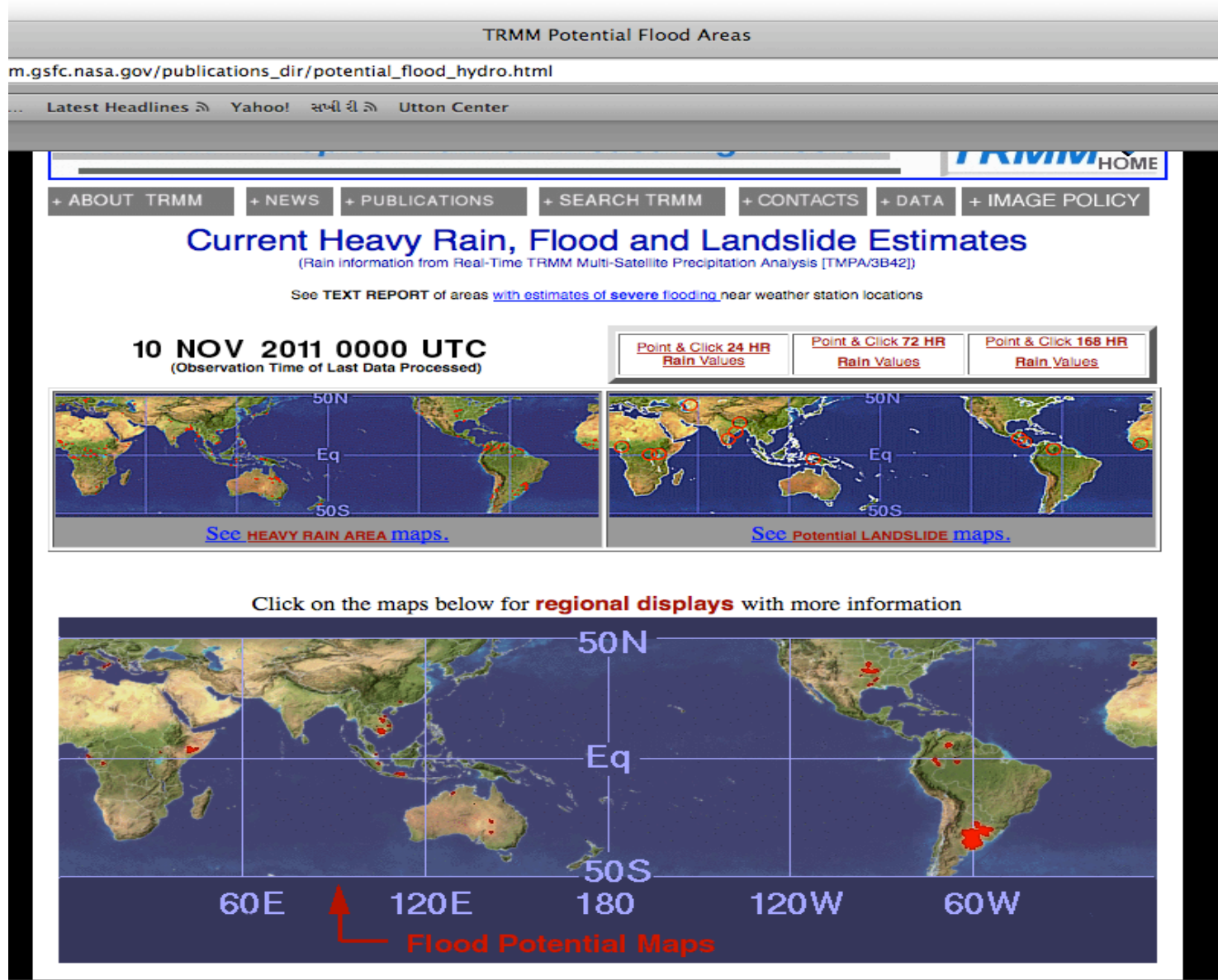
GrADS: COLA/IGES

Generated by NASA's Giovanni ([giovanni.gsfc.nasa.gov](http://giovanni.gsfc.nasa.gov))

2012-05-15-18:32

# TRMM Near-real Time Flood and Landslide Information Tool

([http://trmm.gsfc.nasa.gov/publications\\_dir/potential\\_flood\\_hydro.html](http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html))



# Thank You!

# **TRMM Precipitation Radar (PR)**

## **Technological Challenges**

The spaceborne radar requires enough power to detect the weak return echo from the rain drops when seen from TRMM's orbital height

High resolution three-dimensional maps of the rain during the brief time that the satellite overflies local storms.

The spaceborne radar needs to produce a narrow radiating beam so that the target area would be small enough to bring out the features of interest on the ground- that is, good ground resolution.

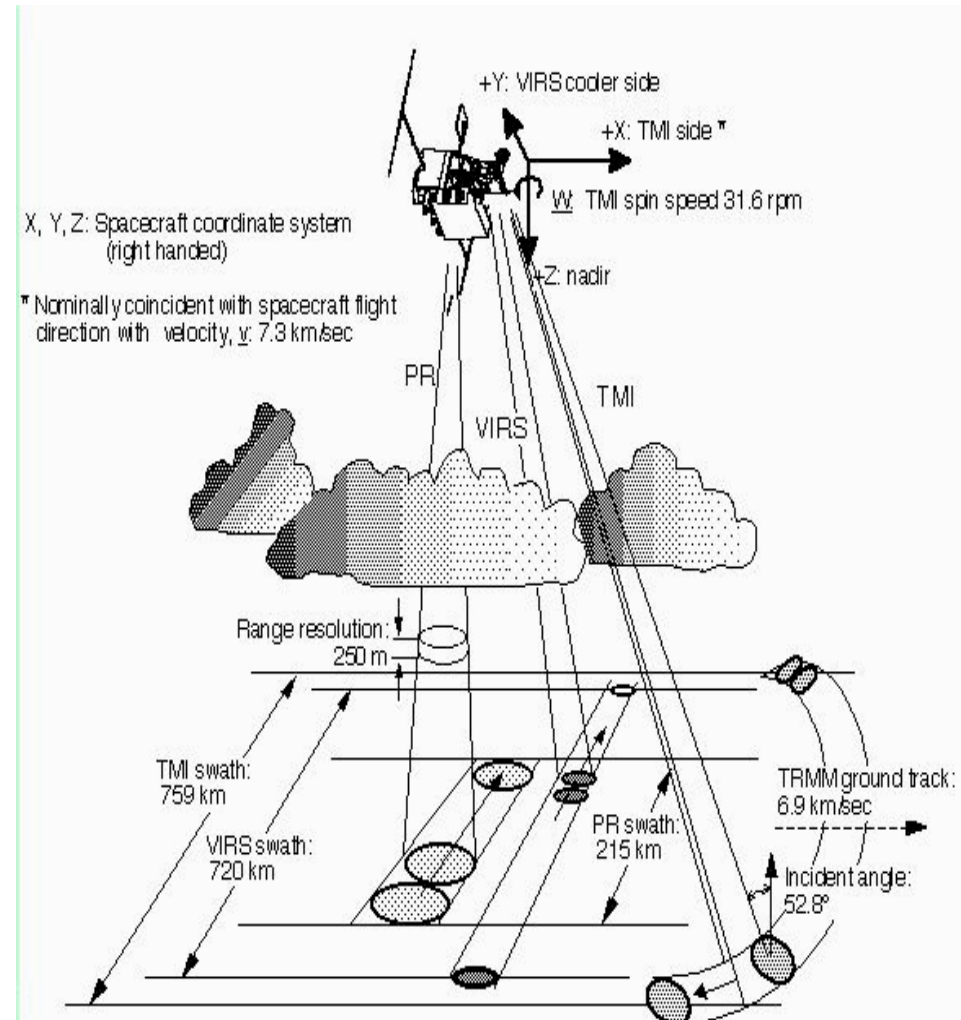
Make the beam sweep out a path on the ground that would be wide enough to give good coverage as the satellite moves along its orbit.



# TRMM Rain Sensing Instruments

The availability of multiple rainfall products from the various TRMM rainfall sensors is due to the fact that each one has various strengths and weaknesses.

The "best" rainfall estimate is application dependent. The TRMM PR provides the highest spatial resolution (~4 km), the best vertical resolution (80 levels), but has the swath width 1/3<sup>rd</sup> of the TMI swath width resulting in poorer sampling.



# TRMM Rainfall products

